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Frequency Selective Filters for Estimating the Equivalent Circuit Parameters of Li-Ion Battery

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Abstract : The most difficult part of designing a battery management system (BMS) is battery modeling. A good battery model can capture the dynamics which helps in energy management, by accurate model-based state estimation algorithms. So far the most suitable and fruitful model is the equivalent circuit model (ECM). However, in real-time applications, the model parameters are time-varying, changes with current, temperature, state of charge (SOC), and aging of the battery and this make a great impact on the performance of the model. Therefore, to increase the equivalent circuit model performance, the parameter estimation has been carried out in the frequency domain. The battery is a very complex system, which is associated with various chemical reactions and heat generation. Therefore, it's very difficult to select the optimal model structure. As we know, if the model order is increased, the model accuracy will be improved automatically. However, the higher order model will face the tendency of over-parameterization and unfavorable prediction capability, while the model complexity will increase enormously. In the time domain, it becomes difficult to solve higher order differential equations as the model order increases. This problem can be resolved by frequency domain analysis, where the overall computational problems due to ill-conditioning reduce. In the frequency domain, several dominating frequencies can be found in the input as well as output data. The selective frequency domain estimation has been carried out, first by estimating the frequencies of the input and output by subspace decomposition, then by choosing the specific bands from the most dominating to the least, while carrying out the least-square, recursive least square and Kalman Filter based parameter estimation. In this paper, a second order battery model consisting of three resistors, two capacitors, and one SOC controlled voltage source has been chosen. For model identification and validation hybrid pulse power characterization (HPPC) tests have been carried out on a 2.6 Ah $LiFePO_4$ battery.

Keywords : equivalent circuit model, frequency estimation, parameter estimation, subspace decomposition
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